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The sessions were organized as follows: 1) Visual Performance, 2) Signal Transduction and Modulation in ON Bipolar cells, 3) Mechanisms and Functions of Gap Junction Coupling, 4) Ionic Channels to Machines, 5) Synaptic Mechanisms in the Outer Plexiform Layer, 6) "Potpourri" (Speakers selected from those who submitted poster abstracts), 7) GABAc Receptors, 8) Synaptic Processes in the Inner Plexiform Layer and 9) Ecology of Vision. The response to this conference was very enthusiastic. Thirteen of 59 participants who completed evaluation forms ranked the meetinga s the best conference they had attended. 41 of 59 ranked it as being in the top 10%. The attendance has grown steadily since the first conference on retina was held in 1992.

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FINAL REPORT

United States Air Force

CONFERENCE GRANT:	FASEB Summer Research Conference on Retinal Neurobiology and Visual Processing
GRANT NUMBER:	F49620-96-1-0128
PERFORMANCE PERIOD:	5/01/96 through 4/30/97
GRANT AMOUNT:	$7,500
PRINCIPAL INVESTIGATOR:	David Copenhagen
GRANTEE INSTITUTION:	Federation of American Societies for Experimental Biology 9650 Rockville Pike Bethesda, MD 20814-3998
DATE OF REPORT:	October 3, 1996

FASEB Summer Conference
July 13-18, 1996
Saxtons River

RETINAL NEUROBIOLOGY AND VISUAL PROCESSING

This meeting was the third Summer Conference focused on the retina. There were 30 invited speakers who were divided about evenly into 9 sessions. The participants were a good mix of younger and more established scientists from within US. and abroad. Age-wise most of the participants fell evenly into groups of 30, 40 and 50 year-olds. Discipline-wise, we drew participants from areas in molecular biology through computational neuroscience.

The sessions were organized as follows: 1) Visual Performance, 2) Signal Transduction and Modulation in ON Bipolar cells, 3) Mechanisms and Functions of Gap Junction Coupling, 4) Ionic Channels to Machines, 5) Synaptic Mechanisms in the Outer Plexiform Layer, 6) "Potpourri" (Speakers selected from those who submitted poster abstracts), 7) $GABA_C$ Receptors, 8) Synaptic Processes in the Inner Plexiform Layer and 9) Ecology of Vision. The first session highlighted how the retina sculpts and limits visual performance. A particularly striking talk by Tom Reuter tied the visual performance of prey catching in toads to the "noise" generated in rods of this animal. The session on ON Bipolar cells included a talk by Duvoisin who was attempting to clone the elusive cGMP-gated channel in these neurons and a paper by Laura Frishman who was able for the first time to dissect the signal generated by ON bipolar when recording from anesthetized cats. This technique promises to be useful to diagnose visual function in human subjects. In the gap junction coupling sessions the talks were highlighted by work of Massey and Mills who are beginning to dissect the differences in various retinal gap junction complexes by observing the differential flow of different-sized dye molecules between coupled cells. The session on ionic channels flowed seamlessly from discussion of specific ion channels in different fly eyes to a video-taped presentation of a robot whose visual behavior was based on the circuitry of the fly's visual system. In the synaptic mechanisms session, the topics ranged from the regulatory processes that might control the release of glutamate from rods and cones to how the glutamate actually diffuses to the postsynaptic cells to the neuromodulatory actions of glutamate. It is clear that the speakers are working in an intensely-studied and very productive area that promises to be an exemplary system to understand glutamatergic synaptic transmission.

In order to provide opportunities for "hot, new" topics, we devoted one session to platform presentations from poster submissions. All of the talks were well received. The topics ranged from an examination of the calcium currents in mouse bipolar cells to the waves of calcium that course through neonatal retinas during development to a new behavioral test for zebrafish vision. A new receptor for the inhibitory neurotransmitter GABA was discovered recently. This receptor is known to control synaptic transmission from bipolar cells to ganglion cells. Our session on these $GABA_C$ receptors showed that much progress has been made in understanding the functioning of these receptors at the molecular level. For the session on synaptic processing in the inner plexiform layer the speakers presented striking new findings on how

neurotransmitter might be released and on how desensitization of postsynaptic receptors plays a vital role in determining the time course of a light response. In the last session we moved to a survey of ecological and evolutionary issues of visual processing. The talks were highlighted by a presentation of how fish cones are evolved to respond to polarized light. Two speakers discussed their work in a rapidly expanding field that addresses how the retina is "constructed" to optimize the transmission of the visual field representation to the brain with optimal fidelity.

The response to this conference was very enthusiastic. Thirteen of 59 participants who completed evaluation forms ranked the meeting as the best conference they had attended. 41 of 59 ranked it as being in the top 10%. The attendance has grown steadily since the first conference on retina was held in 1992.

In addition to the paper sessions we organized two workshops on subsequent afternoons. These were very well attended and allowed much open discussion of technical and theoretical approaches to studying retinal neurobiology and visual processing. The workshops were prearranged so speakers arrived knowing they would be giving a short informal talk.

We were able to secure funding from the National Science Foundation, Office of Naval Research and the Air Force Office of Research. In addition three instrument companies donated funds.

Every effort was made to facilitate the participation of younger scientists. One of the "rules" we established was that no speaker was invited who talked at the 1994 meeting. We wanted to ensure that more scientists and more laboratories had a chance to present their work. I think this policy helped keep the meeting fresh and interesting. We did ask some of the older, established scientists to chair the sessions and give a 10 minute overview/introduction for the topic. These introductions were very helpful in bringing the graduate students up to speed.

At the business meeting, we unanimously decided to schedule another meeting for 1998 in Saxtons River. The chair of the 1998 meeting will be:

Markus Meister
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Sincerely,

David Copenhagen
Chair, 1996 Summer Conference on
Retinal Neurobiology and Visual
Processing

Schedule of Scientific Sessions and Workshops
(As of June 27, 1996)
(Subject to minor modifications)

14 July

Visual Performance
Moderator: Peter Sterling

8:40-9:00 am Welcome etc.
9:00 Introduction
9:10 am Marty Banks (Title?)
9:55 am Stelios Smirnakis "Retinal processing adapts dynamically to second order image statistics."
10:40 am Coffee Break
11:00 am Tom Reuter "When does the random distribution of discrete photoreceptor events limit the sensitivity of the visual system?"
11:45 am* David Brainard "Behavioral consequences of retinal sampling: interactions between space and color"

2:00-4:00 PM **Workshop: Computational Approaches to Retinal Research**
Moderator: Udi Kaplan

1) Norberto Grzywacz "A model of directional selectivity: the melee among GABA, acetylcholine, and glutamate."
2) Buster Boahen "The role of spatio-temporal highpass filtering in the inner vertebrate retina: A computational approach."
3) William Beaudot "Adaptive and spatiotemporal dynamics in the vertebrate retina: A 'structure to function' approach."
4) Frank Werblin "Computational prediction and experimental verification of a new form of edge-enhancement (without lateral inhibition) in retina."

Signal Transduction and Modulation in On Bipolar Cells
Moderator: David Copenhagen

7:30 pm Introduction
7:40 pm Robert Duvoisin "Identification and characterization of a novel cGMP-gated channel from mouse retina."
8:15 pm Scott Nawy "Kinases and regulation of the mGluR6 cascade."
9:00 pm Laura Frishman "Response kinetics of rod bipolar cells at scotopic levels in thecat. "

15 July

Mechanisms and Functions of Gap Junctional Coupling
Moderator: Steven DeVries

9:00 am Introduction
9:10 am Doug McMahon "Structure, function and modulation of retinal gap junction channels."
9:55 am Steven Mills "Quantitative dye coupling in the retina."
10:40 am Coffee Break
11:00 am Julie Schnapf "Rod/Cone Coupling in the Macaque Retina."
11:45 am Robert Smith "Function of electrical coupling in retinal networks: adaptive filtering and noise reduction."

2:00- 4:00 PM **Workshop: Optical Recording from the Retina**
Moderator: Markus Meister

1) Marla Feller "Using fluorescence imaging to measure patterns of activity in the retinal ganglion cell layer."
2) Ralph Nelson "Use of voltage sensitive dyes in studies of receptor pharmacology in dissociated retinal neurons."
3) Zhuo-Hua Pan "Confocal microscopic imaging of calcium dynamics and regulation in retinal neurons."
4) David Wellis "Imaging activity along neural processes in retinal slices."

Insect Vision: Ionic Channels to Machines
Moderator: Joel Davis

7:30 pm Introduction
7:40 pm Simon Laughlin "Retinal response dynamics and visual ecology."
8:25 pm Roger Hardie "Light-sensitive channels in *Drosophila* photoreceptors."
9:10 pm Nicolas Franceschini "Understanding by reconstructing: the use of sighted robots in robotics and physiology."

16 July

Synaptic Mechanisms in the Outer Plexiform Layer
Moderator: Martin Wilson

9:00 am Introduction
9:10 am Don Dixon "Beyond synaptic excitation, metabotropic glutamate receptor actions in horizontal cells"
9:55 am Paul Witkovsky "Gain of Rod to Horizontal Cell Synaptic Transfer."
10:40 am Coffee Break
11:00 am Rukki Rao-Mirotznik "Functional architecture of the rod synapse."

11:45 am Steven Barnes "Plastic photoreceptors: Ion channel modulation."

Talks selected from poster submissions
(20 min talks, 10 min question and answer)
Moderator: Richard Masland

7:30 pm Introduction
7:40 pm Pedro de la Villa "Calcium currents in the axon terminal of mouse bipolar cells, recorded in retinal slice preparation)
8:05 pm Marla Feller "Spatial and temporal properties of spontaneous wave domains in the developing mammalian retina."
8:30 pm Rich Kramer "Cyclic nucleotide-gated channels in synaptic terminals of retinal cone photoreceptors."
8:55 pm Lei Li "Behavorial analysis of visual sensitivity in adult zebrafish."
9:20 pm Stan Schein "Cone ribbon synapses might supply basal synapses with glutamate."

17 July

GABAc Receptors
Moderator: John Dowling

9:00 am Introduction
9:10 am Ralf Enz "Localization of the $GABA_C$ receptor in the mammalian CNS."
9:55 am Dongxian Zhang "Mechanisms underlying the assembly of functional GABA ρ subunits in oocytes."
10:40 am Coffee Break
11:00 am Haohua Qian "$GABA_C$ receptors in the white perch retina."
11:45 am Tian-Li Wang "GABA ρ receptor: Structure and function."

Synaptic Processes in the Inner Plexiform Layer
Moderator: Aki Kaneko

7:30 pm Introduction
7:40 pm Ruth Heidelberger "ATP and exocytosis at a ribbon synapse."
8:25 pm Martin Wilson "What is a quantum of transmitter?"
9:10 pm Peter Lukasiewicz "AMPA-type glutamate receptors may shape excitatory synaptic inputs to retinal ganglion cells."

18 July

Ecology of Vision
Moderator: Markus Meister

8:30 am Introduction
8:40 am Belinda Chang "Using comparative methods to investigate the evolution of wavelength regulation in visual pigments."
9:25 am Ed Pugh "Double-cones, double-cone mosaics and polarization-difference imaging."
10:10 am Coffee Break
10:30 am Gershon Buchsbaum "Modeling of signal sampling and propagation through multiple retinal cell layers.".
11:15 am Sean McCarthy "Preferential representation of natural scenes in the salamander retina."

* Has indicated a possible conflict of interest.

Retinal Neurobiology and Visual Processing

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FASEB
JEOL USA Inc.
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NSF
Avon Instruments, Inc.
U.S. Air Force
ONR

Recent Papers of the Speakers
(Arranged in alphabetical order for each session)

Visual Performance

Banks

Allen D; Banks MS; Norcia AM . Does chromatic sensitivity develop more slowly than luminance sensitivity? Vision Research, 1993, 33:2553-62

Savage GL; Banks MS . Scotopic visual efficiency: constraints by optics, receptor properties, and rod pooling. Vision Research, 1992, 32:645-56

Banks MS; Sekuler AB; Anderson SJ . Peripheral spatial vision: limits imposed by optics, photoreceptors, and receptor pooling. Journal of the Optical Society of America a. Optics and Imagescience, 1991, 8:1775-87

Brainard

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Williams, D. R., Sekiguchi, N., & Brainard, D. H. (1993). Color, contrast sensitivity, and the cone mosaic. PNAS USA, 90, 9770-9777.

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Reuter

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Aho A.-C., Donner K. and Reuter T. (1993). Retinal origins of the temperature effect on absolute visual sensitivity in frogs. J Physiol 463: 501-521.

Aho A.-C., Donner K., Helenius S., Olesen Larsen L. and Reuter T. (1993). Visual performance of the toad (Bufo bufo) at low light levels: retinal ganglion cell responses and prey-catching accuracy. J Comp Physiol A 172: 671-682.

Leibrock C.S., Reuter T. and Lamb T.D. (1994). Dark adaptation of toad rod photoreceptors following small bleaches. Vision Research 34: 2787-2800.

Smirnakis
S.M. Smirnakis, M.J. Berry, D. K. Warland, W. Bialek, M. Meister, "Retinal Processing Adapts to Image Contrast and Spatial Scale," (manuscript submitted for publication).

S.M. Smirnakis, M.J. Berry, D. K. Warland, W. Bialek, M. Meister, "Dynamics of Adaptation to Changing Spatial Structure in the Tiger Salamander Retina." Abstract, Twenty-fifth Annual Meeting of the Society for Neuroscience, San Diego, CA, November 1995.

S. M. Smirnakis, D.K. Warland, W. Bialek, M. Meister, "Tiger Salamander Retina Adapts to Temporal Contrast Modulation to Improve Coding Efficiency." Abstract, Association of Research in Vision and Ophthalmology Conference, Fort Lauderdale, FL, May 1995

Signal Transduction and Modulation in On Bipolar Cells

Duvoisin
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Frishman
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McMahon
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Mills
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Insect Vision: Ionic Channels to Machines

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Martin, N., Franceschini, N. (1994) Obstacle avoidance and speed control in a mobile vehicle equipped with a compound eye In: 'Intelligent Vehicles', EI. Masaki (Ed.)., M.I.T. Press, Cambridge (U.S.A.), pp. 381-386

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Mura, F., Martin, N., Franceschini (1996) Biologically inspired eye movements for the visually-guided navigation of mobile robots In: 'Proc. 4th European Symposium on Artificial Neural networks', ESANN 96, Bruges, Belgium, M. Verleysen (Ed.), D-Facto, Brussels, pp. 135-147

Hardie
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Rao-Mirotznik
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Rao-Mirotznik, R., A. B. Harkins, G. Buchsbaum, and P. Sterling. (1995) Mammalian rod terminal: architecture of a binary synapse. Neuron 14:561-569.

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Witkovsky
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GABAc Receptors

Enz
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Qian
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Wang
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T-L Wang, A Hackam, W B Guggino, and G R Cutting (1995) A single histidine residue is essential for zinc inhibition of GABA r1 receptors. J. Neuroscience 15:7684-7691

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Synaptic Processes in the Inner Plexiform Layer

Heidelberger

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Lukasiewicz

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Wilson

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